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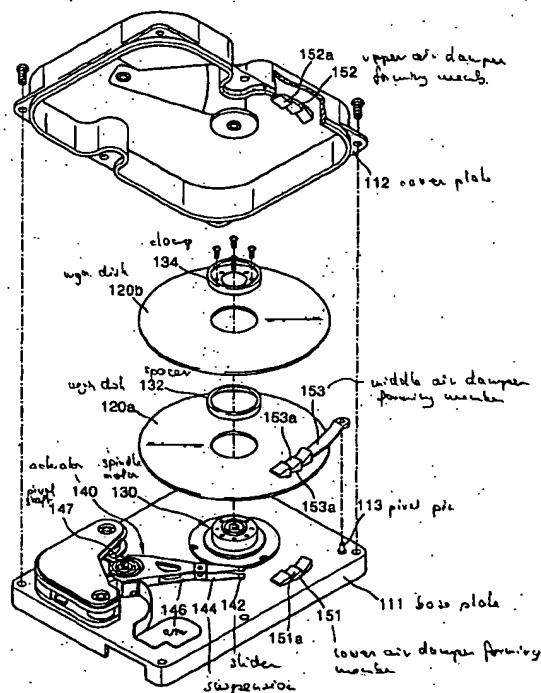
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(54) **Hard disk drive having a disk fluttering reducing unit**

(57) A hard disk drive having a disk fluttering reducing unit includes a lower air damper forming member provided on an upper surface of the base plate to face a bottom surface of an outer circumferential side of the disk, and an upper air damper forming member provided on a bottom surface of the cover plate to face an upper surface of an outer circumferential side of the disk. At least one air compression surface inclined in a circumferential direction of the disk so that a gap with the disk decreases along a rotational direction of the disk is formed at each of the surfaces of the air damper forming members facing the disk. The air compression surface can be inclined in a radial direction of the disk so that a gap with the disk decreases from an inner circumferential side to an outer circumferential side. When at least two disks are provided, a middle air damper forming member can be interposed between the two disks is provided. Thus, disk fluttering is reduced by an air damping operation of the disk fluttering reducing unit so that reliability of data recording and reproducing is improved.

**FIG. 4**



## Description

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

[0001] The present invention relates to a hard disk drive, and more particularly, to hard disk drive having a disk fluttering reducing unit which reduced fluttering of a rotating disk.

#### 2. Description of the Related Art

[0002] A hard disk drive (HDD) is one of auxiliary memory devices of a computer, which reads out data stored in a magnetic disk or records data on the magnetic disk by using a magnetic head. Recently, a variety of researches and developments are being performed to realize a hard disk drive having a high speed, a high capacity, a low fluttering, and a low noise.

[0003] FIG. 1 is a plan view showing a conventional hard disk drive, and FIG. 2 is an enlarged perspective view of a portion of the hard disk drive of FIG. 1.

[0004] Referring to FIGS. 1 and 2, a hard disk drive includes a magnetic disk (a hard disk) 20 which is a recording medium for recording of data, a spindle motor 30 installed on a base 10 to rotate the disk 20, and an actuator 40 having a magnetic head 41 to reproduce the data recorded in the disk 20.

[0005] As the disk 20, a single disk or a plurality of disks are installed to be rotated by the spindle motor 30 and separated a predetermined distance from each other. A parking zone 21 where a slider 42 is accommodated when the power is off is provided at the inner circumferential side of the disk 20, and a data zone 22 where a magnetic signal is recorded is provided outside the parking zone 21. A servo signal for indicating the position of information to be recorded is recorded on several tens of thousands of tracks formed along the circumference of the disk 20.

[0006] The actuator 40 is installed to be capable of pivoting by a voice coil motor 48 around a pivot shaft 47 installed on the base 10. The actuator 40 includes an arm 46 coupled to the pivot shaft 47 to be capable of pivoting, and a suspension 44 which supports a slider 42 installed at the arm 46 to be elastically biased toward the surface of the disk 20. The magnetic head 41 is mounted on the slider 42.

[0007] During the time the power of the hard disk drive is off, the slider 42 is accommodated in the parking zone 21 of the disk 20 by an elastic force of the suspension 44. When the power is turned on and the disk 20 starts to rotate, lift is generated by air pressure and accordingly the slider 42 is lifted. The slider 42 being lifted is moved to the data zone 22 of the disk 20 as the actuator 40 pivots. The slider 42 moved to the data zone 22 of the disk 20 maintains a lifted state at a height where the lift by the rotation of the disk 20 and the elastic force by

the suspension 44 are balanced, as shown in FIG. 3. Thus, the magnetic head 41 mounted on the slider 42 records and reproduces data on and from the disk 20 as it maintains a predetermined distance from the disk 20 that is rotating.

[0008] However, in the conventional hard disk drive having the above structure, fluttering of the disk 20 that is rotating is caused by defective parts of the spindle motor 30, eccentricity in assembly of the disk 20, or irregular air flow in the hard disk drive. As the fluttering, there is RRO (repeatable runout) that is a component repeated at each of rotations and NRRO (non-repeatable runout) that is a component which is not repeated. RRO which regularly repeats can be compensated for by a servo control system to a certain degree whereas NRRO is difficult to be anticipated and compensated. Such disk fluttering deteriorates a data recording and reproduction capability of the magnetic head 41 and finally exerts a bad influence on performance of the hard disk drive.

[0009] Conventionally, when fluttering is generated at the disk 20, an interval between the slider 42 and the disk 20 can be maintained to a certain degree by a damping effect by air existing therebetween. However, as the rotation speed of the disk 20 increases and the thickness of the disk 20 decreases, disk fluttering is amplified so that accurate recording or reproduction of data is made difficult by only the servo control system and the air damping effect between the slider 42 and the disk 20. Further, as TPI (track per inch) increases recently, the disk fluttering makes an accurate control of the position of the magnetic head 41 even more difficult.

[0010] In light of the above, it is necessary to reduce disk fluttering occurring during the operation to secure reliability in its performance. Furthermore, as a hard disk drive recently exhibits a high speed, a high capacity, and a low noise, it is important to reduce disk fluttering.

### SUMMARY OF THE INVENTION

[0011] To solve the above-described problems, it is an object of the present invention to provide a hard disk drive having a disk fluttering reducing unit so that fluttering of a rotating disk is reduced by using an air damping effect.

[0012] To achieve the above object, there is provided a hard disk drive with the features of claim 1.

[0013] Advantageous embodiments of the invention are disclosed by the sub claims.

[0014] Thus, disk fluttering is reduced by an air damping operation of the disk fluttering reducing unit so that reliability of data recording and reproducing is improved.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The above object and advantages of the present invention will become more apparent by describing in detail preferred embodiments thereof with

reference to the attached drawings in which:

FIG. 1 is a plan view showing a conventional hard disk drive;

FIG. 2 is an enlarged perspective view showing a portion of the hard disk drive of FIG. 1;

FIG. 3 is a side view showing a portion of the slider shown in FIG. 2;

FIG. 4 is an exploded perspective view showing a hard disk drive having a disk fluttering reducing unit according to a first preferred embodiment of the present invention;

FIG. 5 is an enlarged side view showing a portion where the disk fluttering reducing unit shown in FIG. 4 is provided;

FIG. 6 is an enlarged perspective view for explaining the operation of the middle air damper forming member shown in FIG. 4;

FIG. 7 is a sectional view showing the air damper forming members shown in FIG. 4, by cutting the same in a radial direction of a disk;

FIG. 8 is a perspective view showing a portion of a hard disk drive having a disk fluttering reducing unit according to a second preferred embodiment of the present invention;

FIG. 9 is a perspective view showing a portion of a hard disk drive having a disk fluttering reducing unit according to a third preferred embodiment of the present invention;

FIGS. 10A and 10C are graphs showing the displacement of fluttering, and the velocity and acceleration of the displacement in the hard disk drive according to the second preferred embodiment of the present invention shown in FIG. 8 in comparison with the conventional hard disk drive.

#### DETAILED DESCRIPTION OF THE INVENTION

[0016] Hereinafter, hard disk drives having a disk fluttering reducing unit according to preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[0017] Referring to FIGS. 4 and 5, a hard disk drive according to a first preferred embodiment of the present invention includes a housing 110 having a predetermined inner space. A spindle motor 130, magnetic disks 120a and 120b, an actuator 140, and a disk fluttering reduction unit 150 are installed in the housing 110.

[0018] The housing 110 is formed of a base plate 111 supporting the spindle motor 130 and the actuator 140 and a cover plate 112 coupled to the base plate 111 and enclosing and protecting the disks 120a and 120b, which are installed inside a main body of a computer. The housing 110 is typically formed of stainless or aluminum material.

[0019] A single or a plurality of the disks 120a and 120b are installed in the housing 110. Conventionally, four or more disks are installed in a hard disk drive to

increase a data storing capacity. Recently, as a recording density of a disk surface increases, only one or two disks can store a sufficient amount of data. Thus, a hard disk drive having one or two disks is a main stream in recent days. Accordingly, a hard disk drive having the two disks 120a and 120b will be used in the description of the present invention. However, the present invention is not limited to a hard disk drive having two disks. It is obvious that the present invention can be applied to a hard disk drive having a single disk or three or more disks.

[0020] The spindle motor 130 is fixedly installed on the base plate 111 to rotate the disks 120a and 120b. When the two disks 120a and 120b are installed at the spindle motor 130, a ring type spacer 132 maintaining an interval between the two disks 120a and 120b is inserted therebetween. A clamp 134 for preventing escape of the disks 120a and 120b is coupled to the upper end portion of the spindle motor 130.

[0021] The actuator 140 is installed on the base plate 111 to be capable of pivoting to record or produce data on or from the disks 120a and 120b. The actuator 140 includes an arm 146 coupled to a pivot shaft 147 to be capable of pivoting and a suspension 144 installed at the arm 146 for supporting a slider 142 where a magnetic head is mounted to be elastically biased toward the surface of the disks 120a and 120b.

[0022] A disk fluttering reducing unit 150 for reducing disk fluttering when the disks 120a and 120b rotate is provided in the hard disk drive according to the present invention. The disk fluttering reducing unit 150 includes a lower air damper forming member 151 provided under the first disk 120a and an upper air damper forming member 152 provided above the second disk 120b. When the two disks 120a and 120b are installed, as shown in the drawings, the disk fluttering reducing unit 150 may further include a middle air damper forming member 153 disposed between the two disks 120a and 120b.

[0023] The air damper forming members 151, 152, and 153 are installed close to and in front of the actuator 140. This is because, as the slider 142 installed at an end portion of the actuator 140 and having the magnetic head mounted thereon and the air damper forming members 151, 152, and 153 are closer to each other, the effect of the disk fluttering reduction by them affects the magnetic head more definitely.

[0024] The air damper forming members 151, 152, and 153 are installed to face the outer circumferential surfaces of the disks 120a and 120b. Also, the air damper forming members 151, 152, and 153 are installed at corresponding positions with the disks 120a and 120b interposed therebetween. In detail, the lower air damper forming member 151 is installed on the upper surface of the base plate 111 to face the bottom surface of the first disk 120a. The upper air damper forming member 152 is installed on the bottom surface of the cover plate 112 to face the upper surface of the second disk 120b.

Preferably, the lower air damper forming member 151 and the upper air damper forming member 152 are integrally formed with the base plate 111 and the cover plate 112, respectively. Since the lower air damper forming member 151 and the upper air damper forming member 152 can be simultaneously formed when the base plate 111 and the cover plate 152 are manufactured, a manufacturing process can be simplified and a manufacturing cost can be lowered. Alternatively, it is possible to fixedly install the lower air damper forming member 151 and the upper air damper forming member 152 at the base plate 111 and the cover plate 112, respectively, after the lower air damper forming member 151 and the upper air damper forming member 152 are manufactured as separate members.

[0025] The middle air damper forming member 153 is installed such that one end portion thereof is coupled to a pivot pin 113 installed to protrude at the corner of the base plate 111 to be capable of pivoting and the other end portion thereof is installed to be interposed between the two disks 120a and 120b. The middle air damper forming member 153 is installed to be capable of pivoting to avoid interference between the disks 120a and 120b and the middle air damper forming member 153 when the disks 120a and 120b are coupled to the spindle motor 130 since the middle air damper forming member 153 is disposed between the two disks 120a and 120b unlike the lower and upper air damper forming members 151 and 152.

[0026] FIG. 6 is a view for explaining the operation of the middle air damper forming member shown in FIG. 4. Referring to FIG. 6, before the first disk 120a is assembled to the spindle motor 130, the middle air damper forming member 153 pivots around the pivot pin 113 so that the other end portion thereof is located outside the base plate 111, as indicated by a dot-dash line in FIG. 6. Next, after the first disk 120a is assembled to the spindle motor 130, the middle air damper forming member 153 is rotated in a direction indicated an arrow so that the other end portion thereof is located above the first disk 120a. Next, the second disk 120b is assembled to the spindle motor 130. Accordingly, the two disks 120a and 120b can be assembled to the spindle motor 130 with interference by the middle air damper forming member 153. In the meantime, the middle air damper forming member 153 can be rotated in the direction indicated by the arrow so that the other end portion thereof can be inserted between the two disks 120a and 120b after the two disks 120a and 120b are assembled to the spindle motor 130.

[0027] Referring back to FIGS. 4 and 5, at least one air compression surface 151 a, 152a, or 153a is formed on each of the surfaces of the air damper forming members 151, 152, and 153 facing the disks 120a and 120b. The air compression surfaces 151a, 152a, and 153a are inclined along the rotational direction of the disks 120a and 120b such that a gap between the air compression surface 151a, 152a, and 153a and the disks 120a and

120b decreases. That is, since the air compression surface 151 a, 152a, and 153a are inclined in the circumferential direction of the disks 120a and 120b, the gap between the air compression surface 151a, 152a, and 153a and the disks 120a and 120b at an air inlet end 151b where air is input is smaller than that at an air outlet end 151c where air is exhausted. For example, the gap  $G_1$  at the air inlet end 151b is about 1-1.5 mm while the gap  $G_2$  at the air outlet end 151c is about 0.1-0.6 mm.

[0028] The air damper forming members 151, 152, and 153 having the air compression surfaces 151 a, 152a, and 153a generate air dampers between the disks 120a and 120b to reduce disk fluttering. That is, the air taken into the air inlet end 151b by the rotation of the disks 120a and 120b is compressed while it flows along the inclined air compression surfaces 151a, 152a, and 153a. Accordingly, pressure by the compressed air is applied to both surfaces of each of the disks 120a and 120b and the pressure by the compressed air applied to both surfaces of each of the disks 120a and 120b reduces disk fluttering. In other words, the compressed air between the disks 120a and 120b and the air compression surfaces 151a, 152a, and 153a produces an air damping effect to reduce disk fluttering. Thus, a stable rotation of the disks 120a and 120b is possible so that the data recording/reproducing capability and reliability of the magnetic head are improved.

[0029] The air compression surfaces 151a, 152a, and 153a may be formed by one at each of the air damper forming members 151, 152, and 153. However, it is preferable to form a plurality of the air compression surfaces in series because the air damper can be formed in a larger area of the disks 120a and 120b.

[0030] The sizes of the gaps  $G_1$  and  $G_2$  can be set appropriately by considering the rotation speed of the disks 120a and 120b and the distance between the two disks 120a end 120b so that a sufficient air damping effect can be obtained. Also, the sizes of the gaps  $G_1$  and  $G_2$  can be set out of the above ranges. In particular, the gap  $G_2$  at the air outlet end 151c is an important factor in the air damping effect. When the gap  $G_2$  is too wide, a sufficient air damping effect cannot be obtained. In contrast, when the gap  $G_2$  is too narrow, the disks 120a and 120b may contact the air damper forming members 151, 152, and 153 by fluttering of the disks 120a and 120b so that the surfaces of the disks 120a and 120b can be damaged.

[0031] FIG. 7 is a sectional view showing the air damper forming members shown in FIG. 4 by cutting it in a radial direction of a disk.

[0032] Referring to FIG. 7, each of the air damper forming members 151, 152, and 153 is inclined such that a gap between the disks 120a and 120b and the air damper forming members 151, 152, and 153 decreases from the inner circumferential side to the outer circumferential side. That is, the air damper forming members 151, 152, and 153 are inclined in the radial direction of the disks 120a and 120b so that a gap  $G_4$  at the edge

portion of the disks 120a and 120b is narrower than a gap  $G_3$  at an inner portion of the disks 120a and 120b. Thus, even when fluttering is generated during rotation of the disks 120a and 120b, the edges of the disks 120a and 120b where no data is recorded contact the air compression surfaces 151a, 152a, and 153a, so that the data recording surfaces of the disks 120a and 120b are prevented from contacting the air compression surfaces 151a, 152a, and 153a.

[0033] FIGS. 8 and 9 show hard disk drives having disk fluttering reducing units according to second and third preferred embodiments of the present inventions, respectively. Here, the same reference numerals used in describing the first preferred embodiment shown in FIG. 4 indicate the same elements.

[0034] Referring to FIG. 8, first, in a hard disk drive according to a second preferred embodiment of the present invention, a set of air damper forming members 251, 252, and 253 of a disk fluttering reducing unit 250 is provided at two positions corresponding to each other with respect to the spindle motor 130. That is, the air damper forming members 251, 252, and 253 are provided not only in front of the actuator 140, but also at a position separated by  $180^\circ$  therefrom in a circumferential direction of the disks 120a and 120b. The structure, installation method, and operation of each of the air damper forming members 251, 252, and 253 are the same as those of the above-described first preferred embodiment. When the disk fluttering reducing unit 250 is provided at two positions, since the forces applied by the air damper forming members 251, 252, and 253 to the disks 120a and 120b are balanced, the disks 120a and 120b can rotate stably.

[0035] Next, referring to FIG. 9, in a hard disk drive according to a third preferred embodiment of the present invention, the air damper forming members 351, 352, and 353 of a disk fluttering reducing unit 350 are installed to face the overall surface at the outer circumference of the disks 120a and 120b except for a range of the operation of the actuator 140. That is, each of the air damper forming members 351, 352, and 353 has a "C" shape in which a portion interfering with the arm 146 of the actuator 140 is open. The structure, installation method, and operation of each of the air damper forming members 351, 352, and 353 are the same as those of the above-described first preferred embodiment. In detail, a plurality of air compression surfaces 351a, 352a, and 353a are sequentially formed at the surfaces of the air damper forming members 351, 352, and 353 facing the disks 120a and 120b along the circumferential direction of the disks 120a and 120b. Also, the middle air damper forming member 353 is divided into at least two parts, and each of the parts is coupled to the pivot pin 113 protruding from the base plate 111 to be capable of pivoting. According to the air damper forming members 351, 352, and 353 having a C shape with an open part, since a uniform force is substantially applied to the overall outer circumference of the disks 120a and 120b, not

only fluttering of the disks 120a and 120b is further reduced, but also the disks 120a and 120b can rotate stably.

[0036] The disk fluttering effect in the hard disk drive having a disk fluttering reducing unit according to the present invention is described below in comparison with the conventional hard disk drive.

[0037] FIGS. 10A through 10C are graphs showing the displacement of fluttering, and the velocity and acceleration of the displacement in the hard disk drive according to the second preferred embodiment of the present invention shown in FIG. 8 in comparison with the conventional hard disk drive. Here, the graphs show the results of a test under the conditions that air damper forming members having one air compression surface, a 15 mm width in a radial direction of a disk, and a 30 mm length in a circumferential direction of the disk are installed to have the maximum gap ( $G_1$  of FIG. 5) of 1.2 mm and the minimum gap ( $G_2$  of FIG. 5) of 0.1 mm from the disk.

[0038] First, FIG. 10A shows the maximum displacement of disk fluttering according to frequencies. Here, it can be seen that the maximum displacement of disk fluttering in a hard disk drive having the air damper forming members according to the present invention is reduced by about 50% compared to that of the conventional hard disk drive which does not have the air damper forming members.

[0039] FIG. 10B shows the velocity of the displacement of disk fluttering according to frequencies. FIG. 10C shows the acceleration of the displacement of disk fluttering according to frequencies. Referring to FIGS. 10B and 10C, it can be seen that the velocity and acceleration of the displacement in a hard disk drive having the air damper forming members according to the present invention are lower by about 50% than those of the conventional hard disk drive.

[0040] In light of the above, it can be seen that, according to a hard disk drive having a disk fluttering reducing unit according to the present invention, disk fluttering is considerably reduced compared to the conventional technology. In particular, the disk fluttering reducing effect is noticeable in a relatively low frequency area (600-750 Hz) and a relatively high frequency area (950 Hz or more). Accordingly, although in the conventional hard disk drive a deviation of values of the displacement, velocity, and acceleration of disk fluttering according to frequencies are very great, the deviation of the values according to frequencies is remarkably reduced.

[0041] As described above, according to the hard disk drive having a disk fluttering reducing unit according to the present invention, since disk fluttering is reduced by the air damping operation of the disk fluttering reducing unit, reliability in data recording/reproducing is improved. Also, noise caused by disk fluttering is reduced as the disk fluttering is reduced.

[0042] While this invention has been particularly shown and described with reference to preferred em-

bodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

## Claims

### 1. A hard disk drive comprising:

a housing (110) having a base plate (111) and a cover plate (112);

a spindle motor (130) installed on the base plate (111);

at least one disk (120a, b) installed at the spindle motor (130);

an actuator (140) installed on the base plate (111) to be capable of pivoting and having at least one magnetic head to record and reproduce data on and from the disk (120a, b), and

a disk fluttering reducing unit (150, 250, 350) forming an air damper above the surface of the disk (120a, b) to reduce fluttering of the disk, **characterized in that** said disk fluttering reducing unit at least comprises:

a lower air damper forming member (151, 251, 351) provided on an upper surface of the base plate (111) to face a bottom surface of an outer circumferential side of a disk (120a, b);

an upper air damper forming member (152, 252, 352) provided on the bottom surface of the cover plate (112) to face an upper surface of an outer circumferential side of a disk (120a, b) and

at least one air compression surface (151a, 152a, 251a, 252a, 351a, 352a) inclined in a circumferential direction of the disk so that a gap (G1, G2) which is formed between each of the surfaces of the air damper-forming members facing the disk and the disk decreases at least along a rotational direction of the disk.

2. The hard disk drive according to claim 1, **characterized in that** in case of two or more disks (120a, b) the lower air damper forming member faces the bottom surface of the lower most disk, the upper air damper forming member faces the upper surface of the upper most disk, and the middle air damper

forming member (153, 253, 353) is interposed between two adjacent disks (120a, b).

3. The hard disk drive according to claim 1 or 2, **characterized in that** the lower air damper forming member (151, 251, 351) is integrally formed with the base plate (111) and/or the upper air damper forming member (152, 252, 352) is integrally formed with the cover plate (112).

4. The hard disk drive according to one of the previous claims, **characterized in that** the air compression surface is additionally inclined in a radial direction of the disk (120a, b).

5. The hard disk drive according to claim 4, **characterized in that** a gap (G<sub>3</sub>, G<sub>4</sub>) between air compression surface and disk (120a, b) decreases from an inner circumferential side to an outer circumferential side.

6. The hard disk drive according to one of the previous claims, **characterized in that** at least two air compression surfaces are sequentially formed.

7. The hard disk drive according to one of the previous claims, **characterized in that** the disk fluttering reducing unit (150, 250, 350) is provided close to and in front of the actuator (140).

8. The hard disk drive according to one of the previous claims, **characterized in that** the disk fluttering reducing unit (150, 250, 350) is provided at at least two positions with respect to the spindle motor (130).

9. The hard disk drive according to claim 8, **characterized in that** the two positions are opposite to each other relative to the spindle motor (130).

10. The hard disk drive according to one of the previous claims, **characterized in that** each of the air damper forming members of the disk fluttering reducing unit (150, 250, 350) has a C shape in which a portion interfering with the actuator (140) is open, to face an overall surface of an outer circumferential side of the disk (120a, b) except for a range of an operation of the actuator.

11. The hard disk drive according to claim 10, **characterized in that** a plurality of air compression surfaces are sequentially formed from one end portion of each of the air damper forming members to the other end portion thereof along the circumferential direction of the disk (120a, b).

12. The hard disk drive according to one of the previous claims, **characterized in that** the middle air damp-

er forming member (153, 253, 353) is pivotably supported on the base plate (111).

13. The hard disk drive according to one of the previous claims, **characterized in that** the middle air damper forming member (353) is divided into at least two parts and each of the parts is pivotably supported on the base plate (111). 5
14. The hard disk drive according to claim 13, **characterized in that** both parts are pivotably supported by the same pivoting means (130). 10

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FIG. 1 (PRIOR ART)

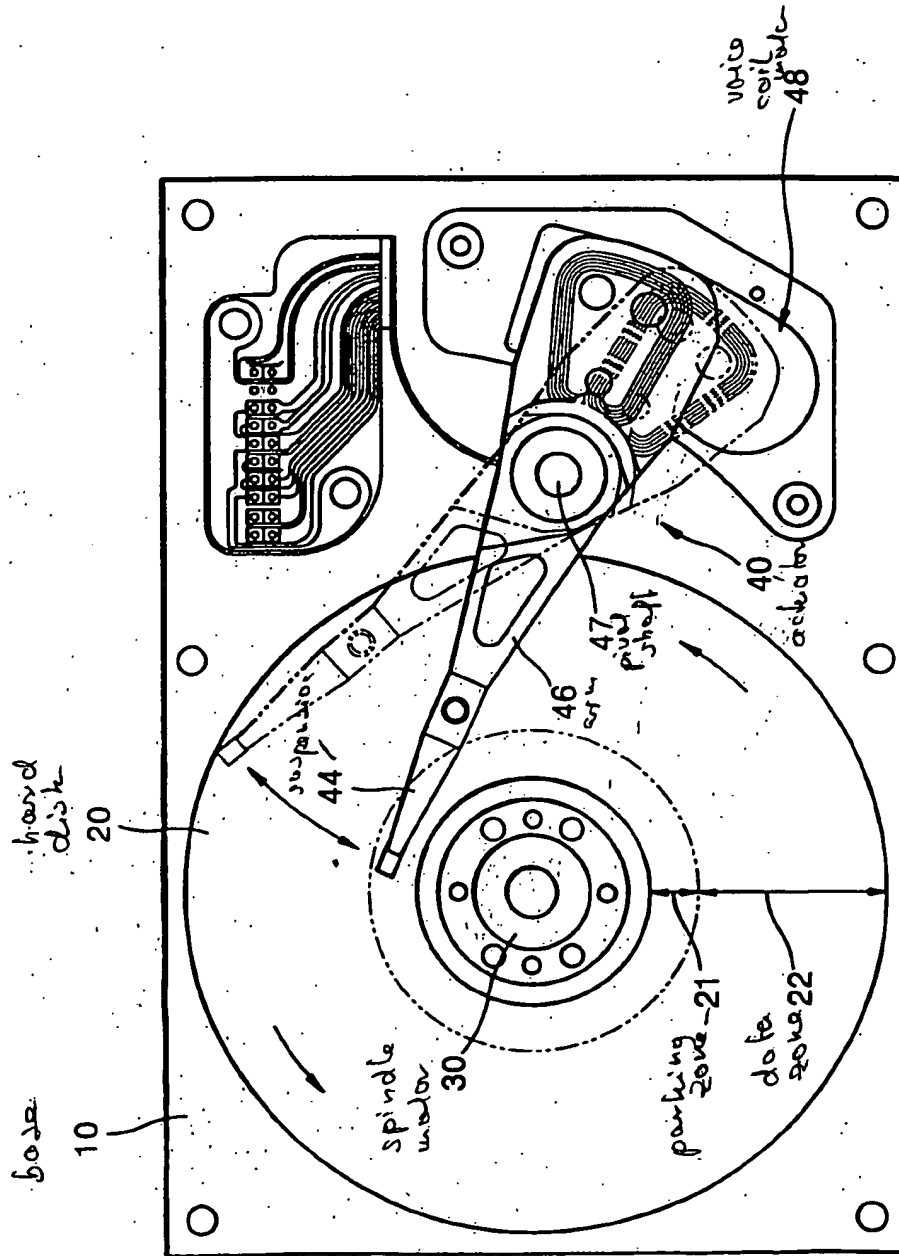




FIG. 4

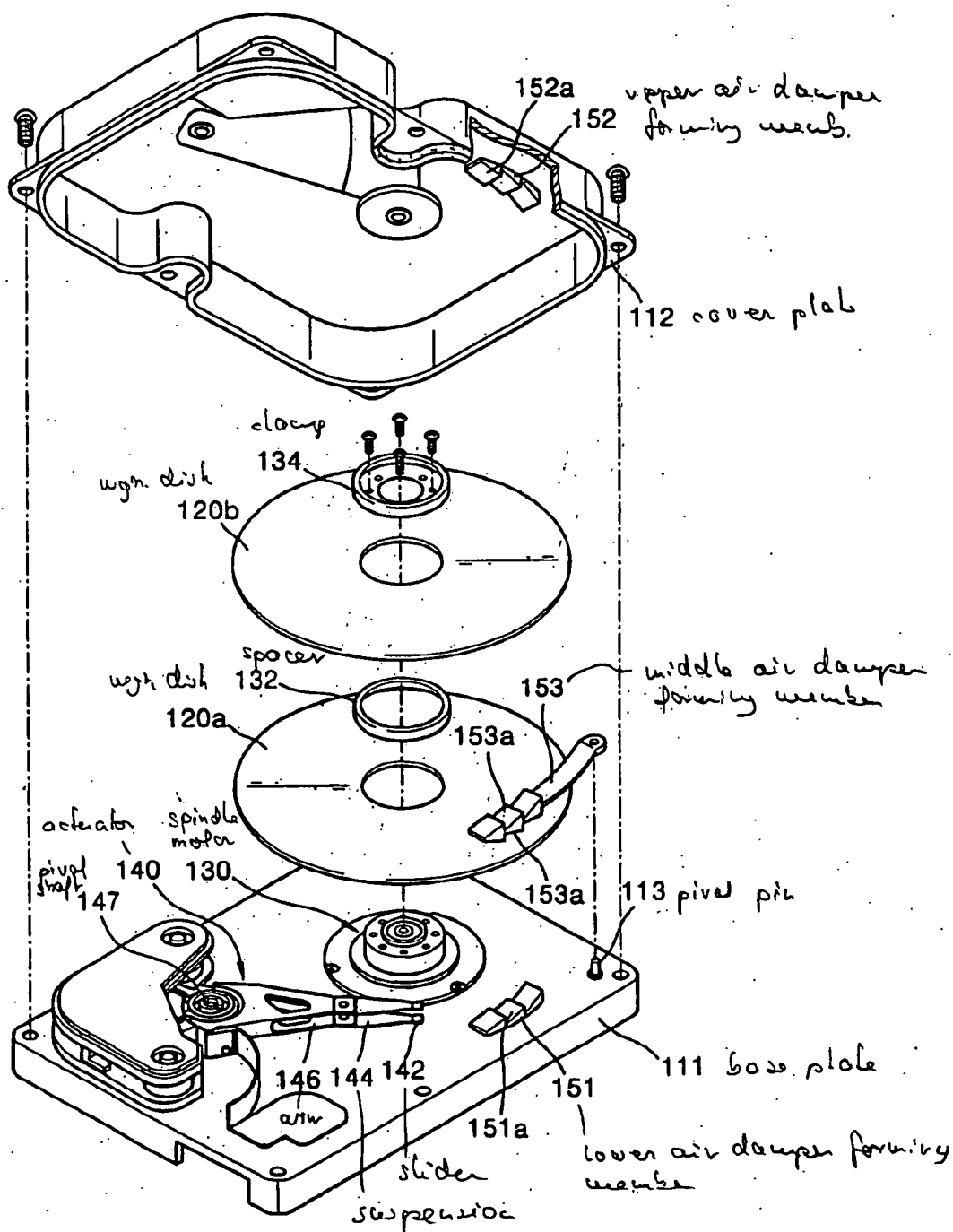


FIG. 5

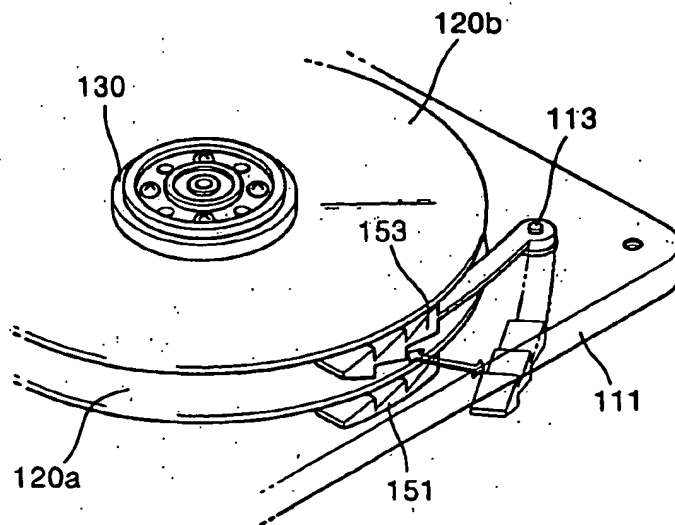
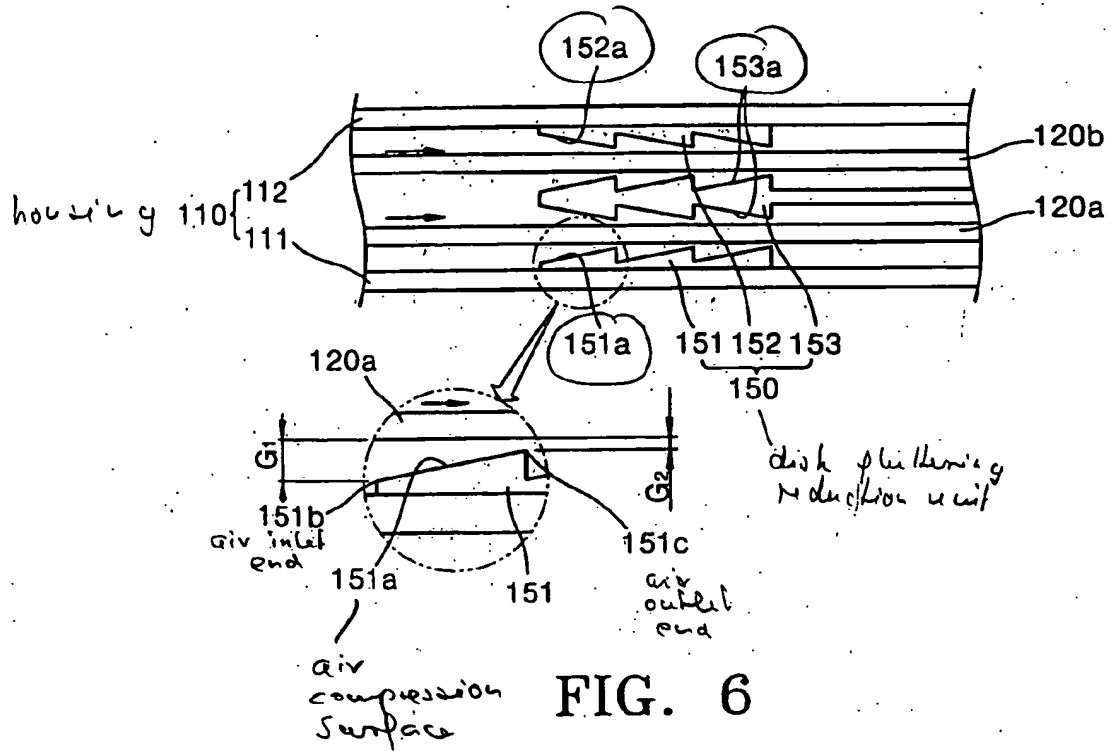




FIG. 9

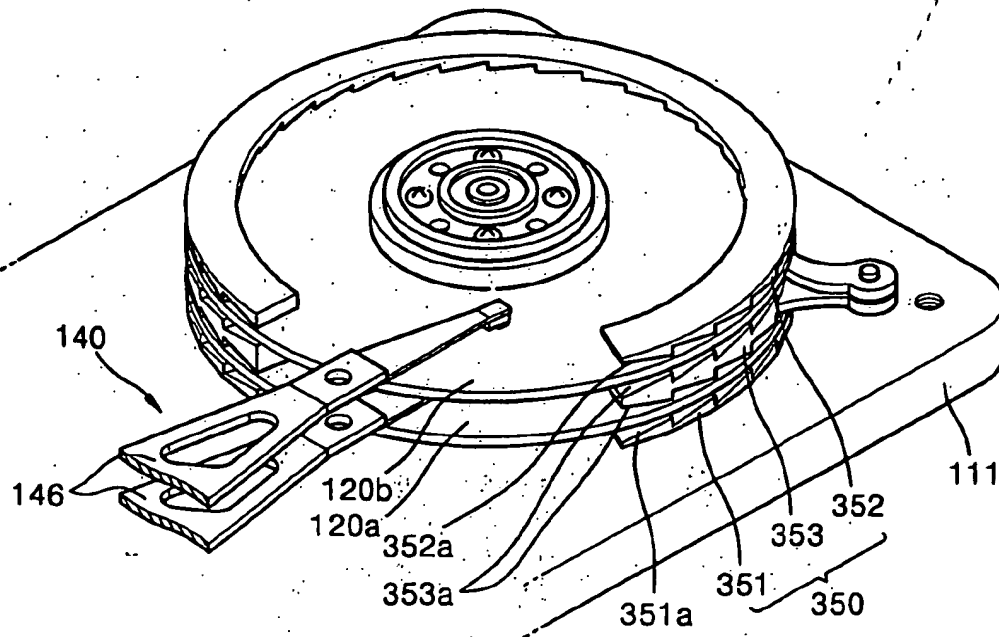


FIG. 10A

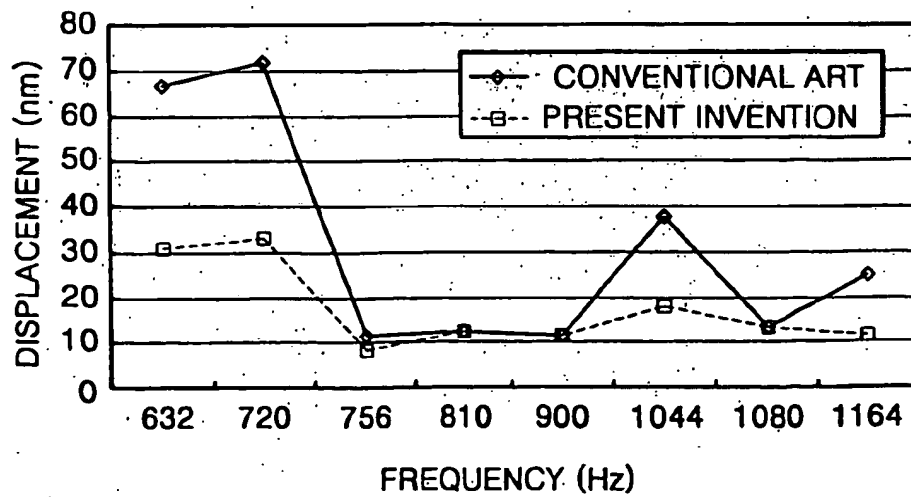


FIG. 10B

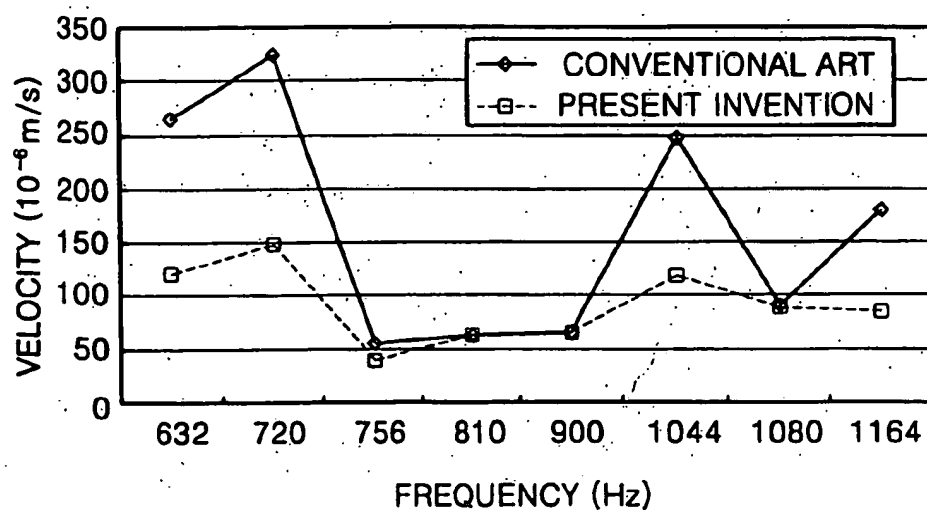


FIG. 10C

